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CYP01-016-CON2-US

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re Application of:	
Tinghao F. Wang	
Serial No. 10/071,809	Examiner Duy Vue Deo
Filing Date: February 7, 2002	Group Art Unit No. 1765
For Method for Selectively Etching Silicon and/or Metal Silicide	

TRANSMITTAL OF APPELLANTS' BRIEF ON APPEAL

M.S. - Appeal Brief
Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

Dear Sir:

Applicants submit the following:

1. Credit Card Payment ($500 for Brief and $450 for two-month extension).
2. Applicant's Brief in Support of the Appeal to the Board of Patent Appeals and Interferences (in triplicate).
3. Two Month Extension of Time (in duplicate).

The Commissioner is hereby authorized to charge any fees associated with this communication **not covered by credit card payment** or credit any overpayment to Deposit Account No. 50-3123. A duplicate copy of this sheet is attached.

Respectfully submitted,

Jonathan M. Blanchard, Ph.D.,
Registration No. 48,927

Evan Law Group LLC
566 West Adams
Suite 350
Chicago, Illinois 60661
(312) 876-1400

Serial No. 10/071,809

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MAR 2 1 2005
PATENT & TRADEMARK OFFICE

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

Inventor:	Tinghao F. Wang
Serial No.:	10/071,809
Filing Date:	February 7, 2002
Title:	METHOD FOR SELECTIVELY ETCHING SILICON AND/OR METAL SILICIDE
Examiner:	DuyVu n Deo
Group Art Unit:	1765

Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

APPLICANT'S BRIEF IN SUPPORT OF THE APPEAL TO THE BOARD OF PATENT APPEALS AND INTERFERENCES

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TABLE OF CONTENTS

I. REAL PARTY IN INTEREST

The real party in interest is Cypress Semiconductor.

II. RELATED APPEALS AND INTERFERENCES

There are no other related appeals or interferences.

III.STATUS OF CLAIMS

All pending claims, claims 1, 3-12, 14-15, 21-23, 25, and 27, have been finally rejected and are appealed. Claims 2, 13, 16-20, 24 and 26 were previously cancelled.

IV.STATUS OF AMENDMENTS

Applicant has filed no amendments subsequent to the final rejection.

V. SUMMARY OF CLAIMED SUBJECT MATTER

WSi_x (metal silicide)/poly-Si (polysilicon) stack structures are used for gate electrodes. (Application: Page 2, Lines 11-13). Dry etching techniques are desirable that will etch a vertical profile through these stack structures without etching through the polysilicon or the gate dielectric that lies beneath the stack. (Application: Page 2, Lines 15-17). Fluorine-based etching gases have high metal silicide etching rates, but undesirably etch polysilicon and the underlying oxide that forms the gate dielectric. (Application: Page 2, Lines 19-21). Chlorine-based etching gases provide higher selectivity than fluorine-based

gases, thus preserving the polysilicon and the oxide layers, but are slower. (Application: Page 2, Lines 22-24).

A prior study by *Nojiri* of chlorine-based etching gases showed that O_2 concentrations in the etching gas of less than 15% by volume have improved metal silicide etch rates, while O_2 concentrations of 25% by volume or more resulted in a halt in the etching process and the deposition of an undesirable film.[1] (Application: Page 3, Lines 1-6). The present invention makes use of the discovery that, contrary to these prior teachings, O_2 concentrations of at least 25% by volume in the chlorine-based etching gas, not only provide high metal silicide etch rates, but selectivity etch metal silicide over polysilicon and oxides at a ratio of at least 30:1. (Application: Page 6, Lines 11-15).

Independent claim 1 provides a method of etching a metal silicide layer while fabricating an integrated circuit in a Cl_2/O_2 gas environment, where the gas includes greater than or equal to 25% O_2 by volume. (Application: Page 4, Lines 1-3). The Cl_2/O_2 gas environment is provided at a pressure of approximately 2 to 40 mili-Torr and the ratio of metal silicide to polysilicon etching is at least 30. (Application: Page 4, Lines 3-4; Page 6, Lines 13-14).

Independent claim 12 provides a method of etching a metal silicide layer while fabricating an integrated circuit in a gas environment including greater

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[1] Nojiri, et al., *J. Vac. Sci. Technol.* B14(3), May/June 1996, p. 1791-1795.

than 25% O_2 by volume. (Application: Page 4, Lines 1-12). The gas environment is provided at a pressure of approximately 2 to 40 mili-Torr and the etching ratio of the metal silicide layer to an underlying polysilicon layer is at least 30. (Application: Page 4, Lines 1-12; Page 6, Lines 13-14).

Independent claim 21 provides a method of etching a metal silicide with a plasma, where the plasma includes a gas mixture including chlorine and greater than 25% O_2 by volume. (Application: Page 4, Lines 1-12; Page 7, Line 18). The etching is carried out at a pressure of approximately 2 to 40 mili-Torr and the ratio of metal silicide to polysilicon etching is at least 30. (Application: Page 4, Lines 4-5; Page 6, Lines 13-14).

VI. GROUNDS OF REJECTION TO BE REVIEWED ON APPEAL

The issues to be decided on this appeal are as follows:

Whether claims 1, 3-12, 14-15, 21-23, 25, and 27 are obvious under 35 U.S.C. § 103(a) over U.S. Pat. No. 5,880,033 to Tsai (*Tsai*) alone, or in view of *Tsai* in combination with U.S. Pat. No. 6,150,250 to Tabara et al. (*Tabara*), or in view of *Tsai* and *Tabara* in combination with Langley et al., *Semiconductor International*, October 1989 (*Langley*).

VII. ARGUMENT

The Examiner has failed to establish a *prima facie* of obviousness for any of the pending independent claims. In particular, each of independent claims 1, 12, and 21 include an etching selective enough to provide a metal silicide to polysilicon etch selectivity of at least 30. The closest metal silicide to polysilicon etching selectivity that may be found in the cited references is 5, found in *Tsai*. (Col. 9, Line 45). Thus, the present invention provides an etching selectivity improvement of at least six times that found in the cited art. Furthermore, *Tsai* teaches away from the present invention, teaching that increasing the oxygen concentration of the etching gas provides an increase in the rate of polysilicon etching and a concurrent decrease in etching selectivity.[2] *Tabara* and *Langley* fail to cure the deficiencies of *Tsai*.

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[2] This is true even though a drafting error resulted in an obvious misdescription of Figures 4 and 5 that states that etching selectivity increased with increasing O_2. (Col. 7, Lines 64-66; Col. 8, Lines 5-7).

A. The Cited References Fail to Render Obvious Under 35 U.S.C. § 103 an Etching Process Providing a Metal Silicide to Polysilicon Etch Selectivity of at Least 30.

1. Independent claims 1, 12, and 21 include a metal silicide to polysilicon etch selectivity of at least 30, a value not provided, suggested, or obtainable from the technology described in the cited references.

To establish a *prima facie* case of obviousness, in addition to a motivation to combine and an expectation of success, the cited art must teach or suggest every element of the claims. M.P.E.P. § 2143 *citing* In re Vaeck, 947 F.2d 488, 20 USPQ2d 1438 (Fed. Cir. 1991). Even though *Tsai* is directed to the same goals as the present application, providing a high etching rate while selectivity etching a metal silicide over polysilicon, the best selectivity obtained in *Tsai* was a 5:1 etching ratio of metal silicide to polysilicon. (Col. 9, Line 45). Thus, *Tsai* cannot teach or suggest the claimed etching selectivity of at least 30 (same as a 30:1 ratio).

If the teachings of *Tsai* could have made the presently claimed selectivity value of 30 obvious, *Tsai* would have obtained this higher etching selectivity because the reference is directed to same problem as Applicant's invention, high etching selectivity. Instead of being obvious over *Tsai's* selectivity ratio of 5, the at least 30 etching ratio of present claims 1, 12, and 21 provides a substantial improvement, a six time increase in etching selectivity.

Tsai could not have obtained etching selectivity ratios higher than 5 at least because the highest concentration of O_2 used in the etchant gas was approximately 14% of the total gas volume. (Col. 3, Lines 25-28). In the Examples, only 3% O_2 was actually used. (Col. 9, Lines 24-26). The O_2 percentages of *Tsai* are substantially lower than those of the present claims, where at least 25% O_2 is indicated. The present claims use a significantly higher concentration of O_2 in the etchant gas to obtain the markedly higher etching selectivity of at least 30.

Neither could *Tsai* have suggested that Applicant's higher percentage of O_2 in the etchant gas could increase etching selectivity to provide the at least 30 value of the present claims for at least two reasons. First, *Tsai* explicitly teaches away from higher O_2 concentrations, stating that "excessively high[3] flow rates of the oxygen gas can cause more isotropic etching of the substrate ... and can also result in excessively low dielectric etch rates." (Col. 7, Lines 15-20). Furthermore, this statement from *Tsai* is consistent with the prior teachings of *Nojiri*, which were accepted when *Tsai* was filed and before the unexpected results of the present invention were obtained.

Second, *Tsai* could not suggest the at least 30 selectivity value of the present claims because the experimental data presented in *Tsai* also teaches

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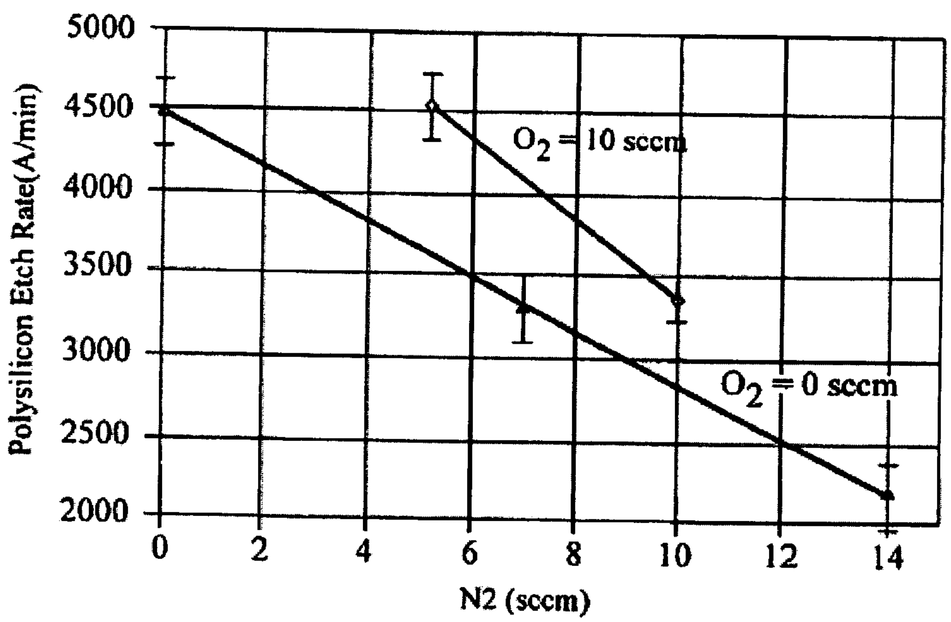
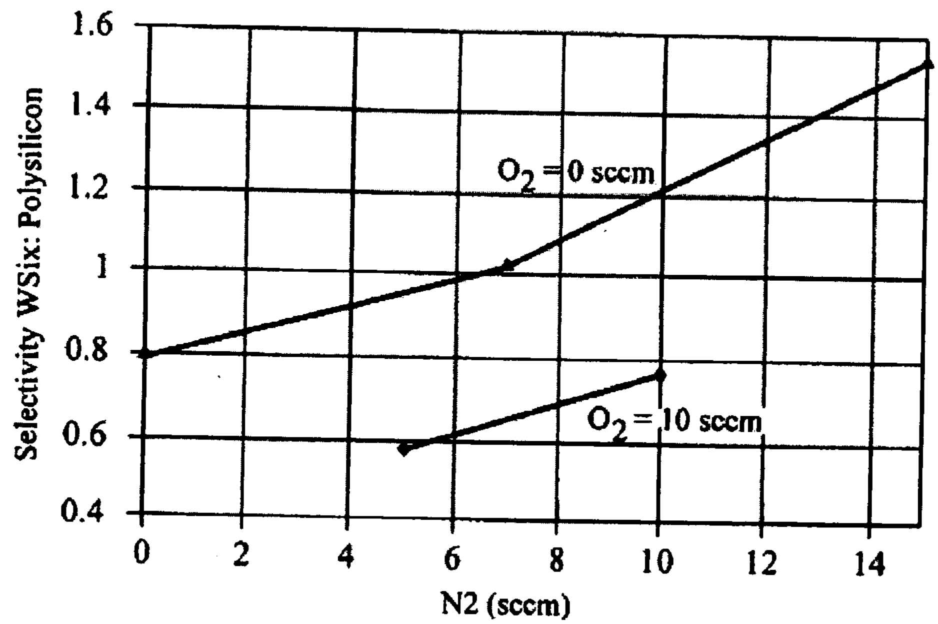
[3] While "excessively high" may not be numerically specific, one of ordinary skill in the art would understand the presently claimed value of at least 25% to be "excessively higher" than the 3% to 7% values used in *Tsai*.

away from Applicant's use of high O_2 concentration to provide significantly increased selectivity. Figure 3 of *Tsai* establishes that when the O_2 concentration of the etchant gas is increased from 0 to about 7%, a beneficial increase in the rate of metal silicide etching results. However, Figure 4, reproduced below, shows that the same ~7% increase in the O_2 concentration of the etchant gas has the undesirable side effect of concurrently increasing the rate of polysilicon etching. In fact, when the O_2 concentration of the etching gas was increased from 0 to about 7%, the rate of polysilicon increased from about 3250 to about 4000 A/min.[4]



[4] These values are at the ~7 sccm N_2 value; however, they are not significantly different at other N_2 flow rates.

Figure 5, reproduced below, compares the rates of metal silicide etching from Figures 3 to the rates of polysilicon etching from Figure 4 as selectivity ratios, with higher selectivity values representing enhanced metal silicide to polysilicon etching. As seen in Figure 5, when the O_2 concentration of the etching gas was increased from 0 to about 7%, the selectivity ratio decreased from about 1 to about 0.65 (an approximately 35% decrease).[5]



The data of *Tsai* show that an increase in the O_2 concentration of the etching gas increases the rate of metal silicide etching, while concurrently reducing the selectivity of metal silicide to polysilicon etching. Not a single data

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[5] These values are at the ~7 sccm N_2 value; however, they are not significantly different at other N_2 flow rates.

point obtained with the etching gas containing ~7% O_2 had an etching selectivity greater than that obtained with the etching gas lacking O_2.[6]

Tsai does not disclose and cannot suggest the use of etching gases having higher O_2 concentrations to obtain enhanced etching selectivity because the data only show a decrease in etching selectivity with higher O_2 content. *Tsai* cannot suggest the opposite of what it describes and can only teach away from claims 1, 12, and 21, where a 25% or greater concentration of O_2 in the etchant gas provided an etching selectivity of at least 30.

The Examiner has failed to establish a *prima facie* case of obviousness because *Tsai* fails to disclose or suggest that an etching selectivity of at least 30 (a 6 time increase over the highest obtained by *Tsai*) could be obtained by increasing the O_2 concentration of the etchant gas from the 3% of *Tsai* to greater than or equal to 25%. When considered as a whole, *Tsai* teaches that increasing the O_2 concentration of a chlorine-based etchant gas provides a desirable increase in the rate of metal silicide etching while concurrently providing an undesirable decrease in metal silicide to polysilicon etching that may be partially

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[6] The Applicant would like to point out that with regard to Figures 4 and 5, *Tsai* states that "the polysilicon etch rate is lowered for increasing flow rates of O_2 as well as increasing flow rates of N_2" (Fig. 4) and that "the etching selectivity ratios increases [*sic*] for both increasing flow rates of O_2 and increasing flow rates of N_2" (Fig. 5). (Col. 7, lines 64-66; Col. 8, lines 5-7). However, it is clear from the Figures that a drafting error occurred with regards to the "increasing flow rates of O_2" in both passages, which should read "**decreasing** flow rates of O_2." The graphs may not be interpreted in any other manner.

counteracted by adding N_2 gas to the etchant gas.[7] *Tsai* does not describe or suggest the selectivity and O_2 concentrations indicated in present claims 1, 12, and 21. Thus, the rejections over *Tsai* under 35 U.S.C. § 103 must be removed.

The combination of *Tsai* with *Tabara* also fails to establish a *prima facie* case of obviousness with regard to claims 1, 12, and 21 because like *Tsai*, *Tabara* teaches that regardless of the O_2 concentration of the etchant gas, polysilicon is always etched faster than metal silicide. *Tabara* describes the etching of WSi_2 or polysilicon using TiN or TiON as an etching mask. The purpose of *Tabara* is to provide etching conditions that selectively etch the metal silicide or polysilicon layer with respect to the mask. (Col. 2, Lines 49-54). Very similar etching conditions are used to etch both WSi_2 and polysilicon with Cl_2/O_2 etching gases that include from about 31% to about 38% O_2. (Col. 7, lines 9-26).

Figure 20 of *Tabara* establishes that for any attempted O_2 flow rate the etch selectivity of Si/TiN is always greater than the selectivity of WSi_2/TiN.[8] Thus, polysilicon is always etched faster than the WSi_2 metal silicide. *Tabara* provides no suggestion that greater metal silicide etching selectivity, certainly

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[7] A reference must be treated for all it teaches. W.L. Gore & Assocs. v. Garlock, Inc., 721 F.2d 1540, 1551, 220 U.S.P.Q. 303, 312-13 (Fed. Cir. 1983) (stating in determining obviousness, the invention must be considered as a whole without the benefit of hindsight of Applicant's disclosure).

[8] Compare the curve on the upper left with the curve at the bottom; all other curves describe irrelevant WSi_2/TiON etch selection ratios.

not the at least 30 value of present claims 1, 12, and 21, may be obtained for a metal silicide/polysilicon etch. In fact, *Tabara* teaches away from the present invention by showing that regardless of the O_2 concentration, Cl_2/O_2 etchant gases cannot selectively etch a metal silicide over a polysilicon.

Tabara fails to provide *Tsai* with the missing etching selectivity of at least 30, which is an element necessary to establish a *prima facie* case of obviousness. Thus, the 35 U.S.C. § 103 rejections of claims 1, 12, and 21 over *Tsai* in combination with *Tabara* must be withdrawn.

The combination of *Tsai* with *Langley* or *Tabara* with *Langley* also fails to establish a *prima facie* case of obviousness. *Langley* was cited for describing a breakthrough etching using CF_4, a concept present in Applicant's dependent claims 22, 23, and 25. However, *Langley* provides no suggestion regarding how to etch a metal silicide with respect to a polysilicon with a selectivity ratio of at least 30 during a metal silicide etch. Thus, the combination of *Langley* with *Tsai* or *Tabara* cannot establish a *prima facie* case of obviousness with regard to present claims 1, 12, and 21 and the rejections under 35 U.S.C. § 103 must be withdrawn.

2. In addition to the selectivity ratio of at least 30 and the 25% O_2 by volume elements of independent claims 1, 12, and 21, independent claim 1 further indicates that the etchant gas includes Cl_2 and O_2.

A *prima facie* case of obviousness also may not be established for claim 1, because the claim is differentiated from *Tsai* through the exclusion of N_2 gas. To establish a *prima facie* case of obviousness, an expectation of success must be found in the cited reference, not Applicant's disclosure. M.P.E.P. § 2143 *citing* In re Vaeck.

As stated above, *Tsai* teaches that while an increased concentration of O_2 in the etchant gas increases the rate of metal silicide and polysilicon leading to inferior etching selectivity, the selectivity may be improved while maintaining the increased overall etching rate by adding N_2 gas to the mixture. *Tsai* makes this clear by stating that "[t]he nitrogen gas provides unexpected results in combination with chlorine and oxygen gases" and that "[i]ncreasing the nitrogen gas significantly lowers the rate of etching of polysilicon layer 24, without [adversely] affecting the rate of etching of the metal silicide layer 22." (Col. 7, Lines 25-26; Col. 7, Lines 26-29).

Based on the teachings of *Tsai*, one could never expect that a substantial increase in the O_2 concentration of the etchant gas in the absence of N_2 could successfully provide any increase in etching selectivity, certainly not the at least 30 etching ratio of Applicant's claim 1. *Tabara* and *Langley* fail to meaningfully

address metal silicide/polysilicon etching selectivity and, thus, cannot cure the deficiencies of *Tsai*.

Without relying on Applicant's disclosure, the Examiner failed to establish any expectation that one could successfully increase etching selectivity by increasing the O_2 concentration of the etchant gas. Thus, *Tsai, Tabara,* and *Langley*, alone or in combination, cannot establish a *prima facie* case of obviousness with regard to claim 1, and the rejections under 35 U.S.C. § 103 must be withdrawn.

VIII. CONCLUSION

For the foregoing reasons, the claim rejections applied by the Examiner under 35 U.S.C. § 103 are unsustainable. Applicants respectfully request reversal of the Examiner's rejections.

Respectfully submitted,

Dated:

Jonathan M. Blanchard
Registration No. 48,927

Evan Law Group
566 West Adams St., Suite 350
Chicago, IL 60661
(312) 876-1400

IX. CLAIMS APPENDIX

1. (Previously Presented) A method comprising, etching a metal silicide layer during fabrication of an integrated circuit in a $Cl_2/0_2$ environment having an 0_2 concentration of greater than or equal to 25% by volume,

wherein the Cl_2/O_2, environment is provided at a pressure of approximately 2-40 mili-Torr, and wherein the etching is a metal silicide etch that is selective to poly-silicon with a ratio of etch rates of at least 30.

2. (Cancelled)

3. (Original) The method of claim 2 wherein the pressure is approximately 3 mili-Torr.

4. (Original) The method of claim 1 wherein the $Cl_2/0_2$ environment is provided in a reactor with a source power of approximately 200 - 2000 Watts.

5. (Original) The method of claim 4 wherein the source power is approximately 400 Watts.

6. (Original) The method of claim 1 wherein the Cl_2/O_2 environment is provided in a reactor having a bias power of approximately 35 to 400 Watts.

7. (Original) The method of claim 6 wherein the reactor has a bias power of approximately 50 Watts.

8. (Original) The method of claim 1 wherein the metal silicide layer is a tungsten silicide layer.

9. (Original) The method of claim 1 wherein the $Cl_2/0_2$ environment comprises approximately 45 sccm Cl_2 and 30 sccm 0_2.

10. (Original) The method of claim 9 wherein the Cl_2/O_2 environment is provided for a time period sufficient to completely etch the metal silicide layer.

11. (Original) The method of claim 9 wherein the time period is approximately 30 seconds.

12. (Previously Presented) A method comprising etching a metal silicide layer during fabrication of an integrated circuit in an environment having a concentration of 0_2 greater than 25% by volume so as to selectively etch the metal silicide layer with respect to an underlying poly-silicon layer with a ratio of etch rates of at least 30,

wherein the etching is carried out at a pressure of 2-40 mili-Torr.

13. (Cancelled)

14. (Original) The method of claim 12 wherein the environment comprises approximately 45 sccm Cl_2 and 30 sccm 0_2.

15. (Original) The method of claim 12 wherein the metal silicide is chosen from the group consisting of tungsten silicide, chromium silicide and titanium silicide.

16-20. (Cancelled)

21. (Previously Presented) A method of etching a metal silicide, comprising etching of the metal silicide with a plasma,

wherein the plasma is prepared from a gas mixture comprising: chlorine, and greater than 25% by volume oxygen,

the etchinq is carried out at a pressure of 2-40 mili-Torr, and

the etching is a metal silicide etch that is selective to poly-silicon with a ratio of etch rates of at least 30.

22. (Previously Presented) The method of claim 21, further comprising, prior to said etching, a breakthrough etch.

23. (Previously Presented) The method of claim 22, wherein said breakthrough etch comprises etching with a plasma prepared from a gas comprising CF_4.

24. (Cancelled)

25. (Previously Presented) The method of claim 1, further comprising, prior to said etching, a breakthrough etch.

26. (Cancelled)

27. (Previously Presented) The method of claim 21, wherein said gas mixture comprises: chlorine and from 25% to 30% by volume oxygen.